US005722331A

United States Patent [19]

Machael

[11] Patent Number: 5,722,331

[45] Date of Patent: Mar. 3, 1998

[54] **ADJUSTABLE HEIGHT LOAD BEARING SUPPORT STRUCTURE**

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[73] Assignee: **Hon Industries Inc.**, Muscatine, Iowa

[21] Appl. No.: **731,138**

[22] Filed: **Oct. 10, 1996**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 634,592, Apr. 18, 1996.

[51] **Int. Cl.**^{6} **A47B 9/00**

[52] **U.S. Cl.** **108/145**; 108/147; 248/588

[58] **Field of Search** 108/147, 146, 108/144, 145; 248/188.2, 588, 584, 421

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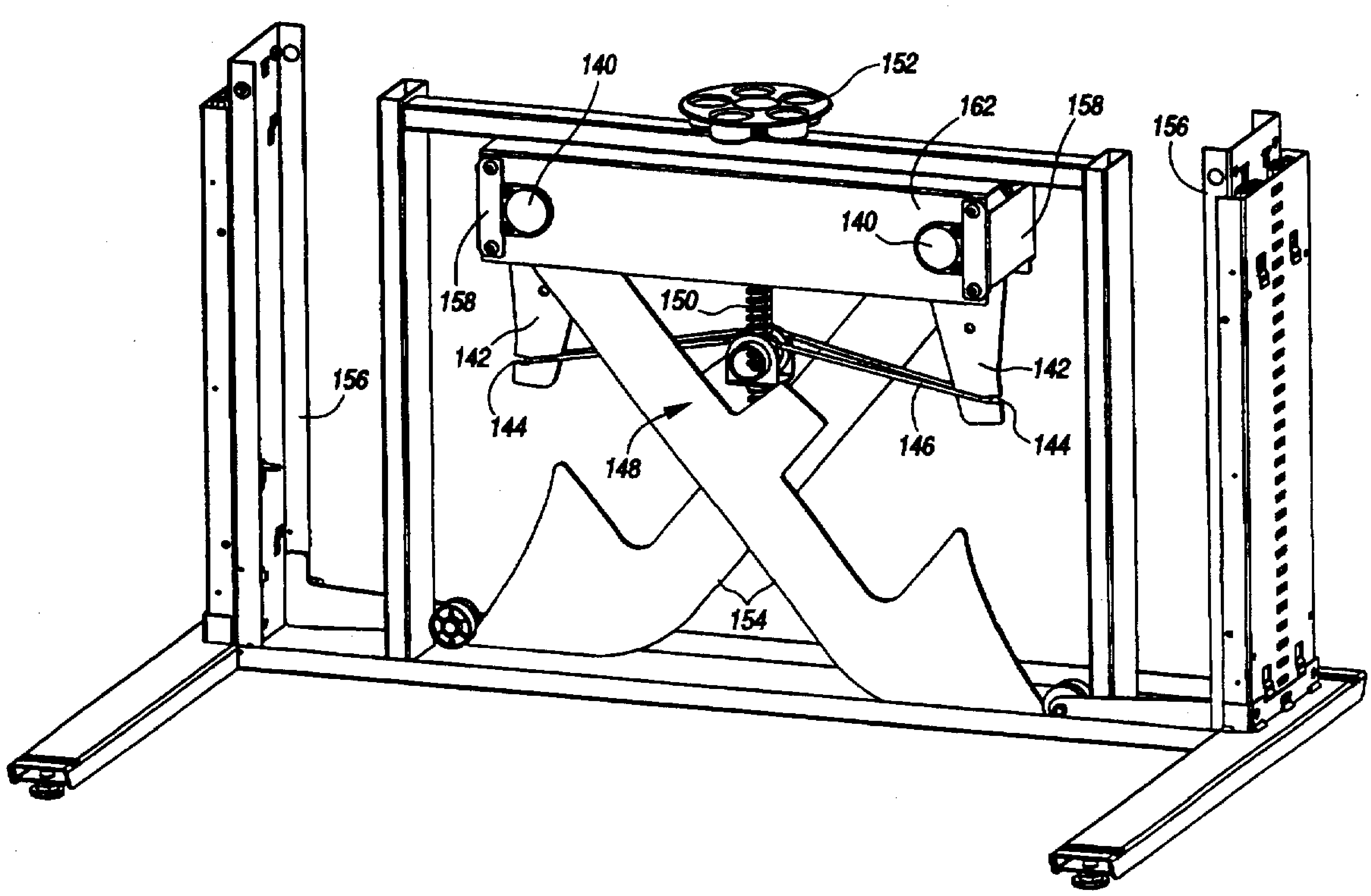
Primary Examiner—Jose V. Chen
Attorney, Agent, or Firm—Jones, Day, Reavis & Pogue

[57] **ABSTRACT**

A counterbalanced adjustable height load bearing support structure with a pretensioning mechanism comprises a pair of pivotable arms each having a free end in engagement with a support assembly and being biased by a torsion spring. A lever arm is connected to each torsion spring and exerts a biasing force on the pivotable arm when the lever is rotated, thereby preloading the springs. A cable connects the lever arms and passes over a central bushing. The bushing receives a threaded shaft which may be turned to move the bushing and thereby adjust the tension in the cable. Because the cable is capable of sliding engagement with the bushing, tension in the cable is substantially uniform throughout its length and thus the resultant forces on the lever arms is approximately equal. Correspondingly, the forces on the two pivotable arms and associated support assemblies is approximately equal, whereby binding or racking of the support assemblies is minimized as the support surface is raised or lowered.

7 Claims, 16 Drawing Sheets



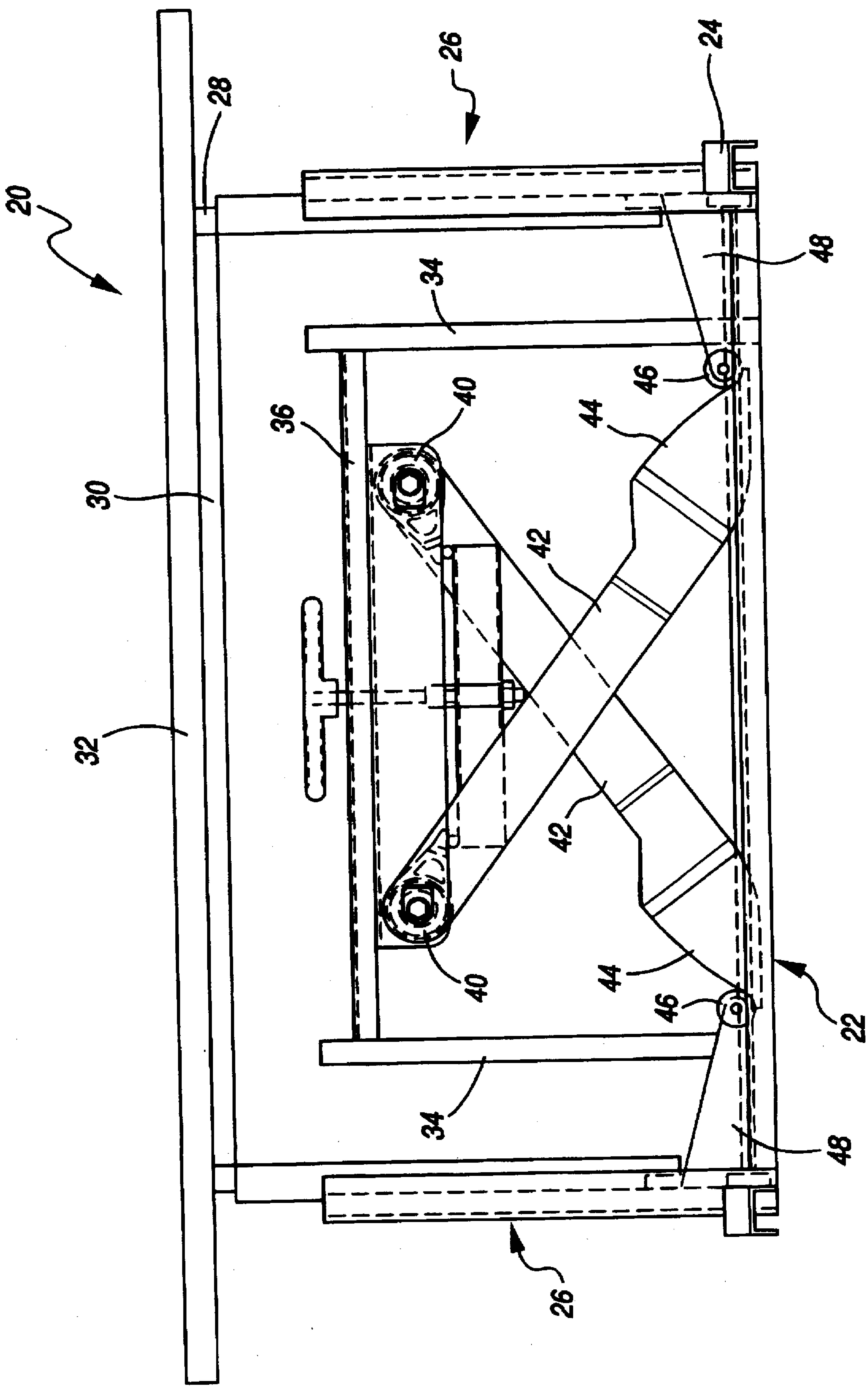


FIG. 1

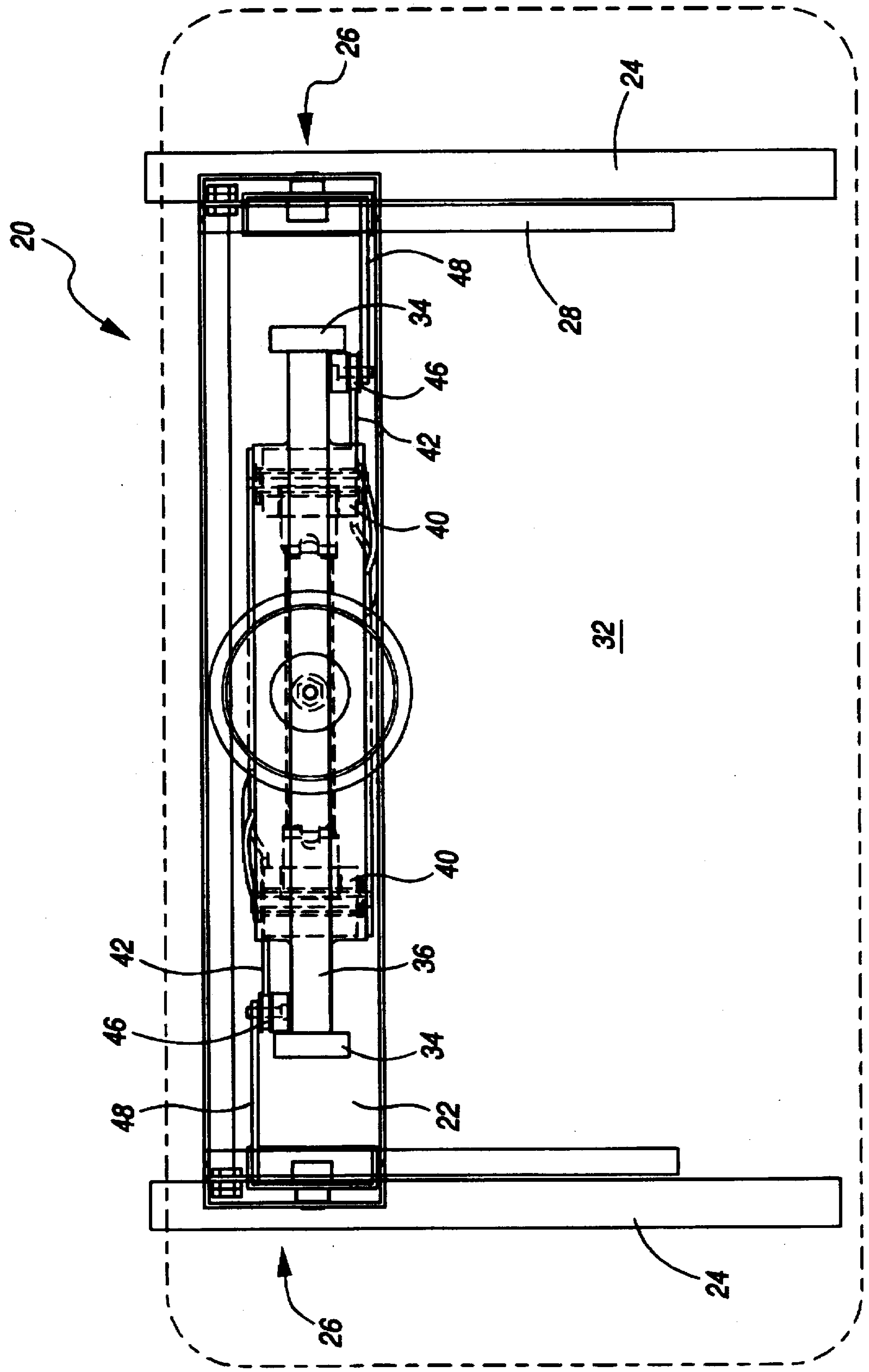
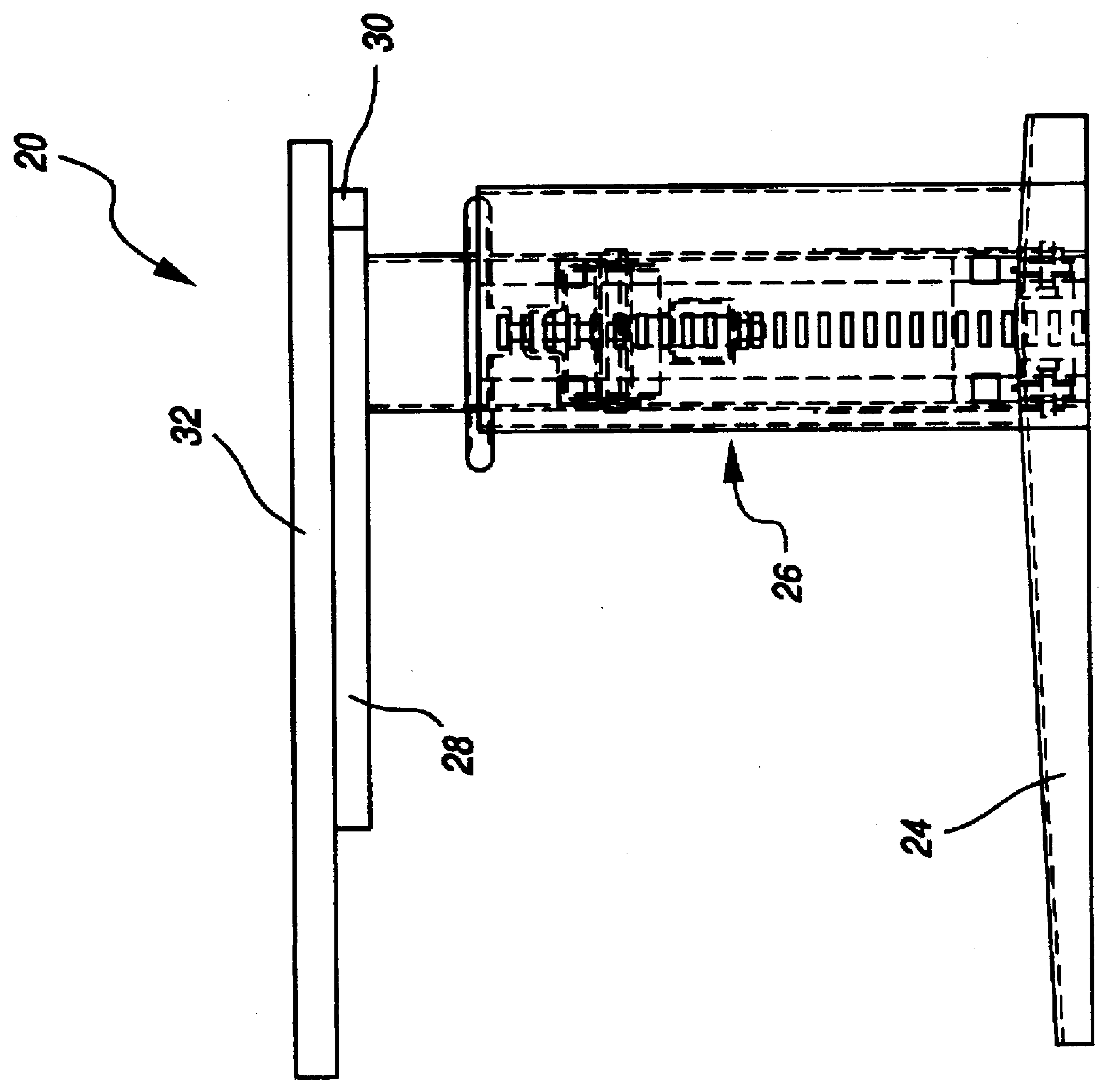


FIG. 2

FIG. 3



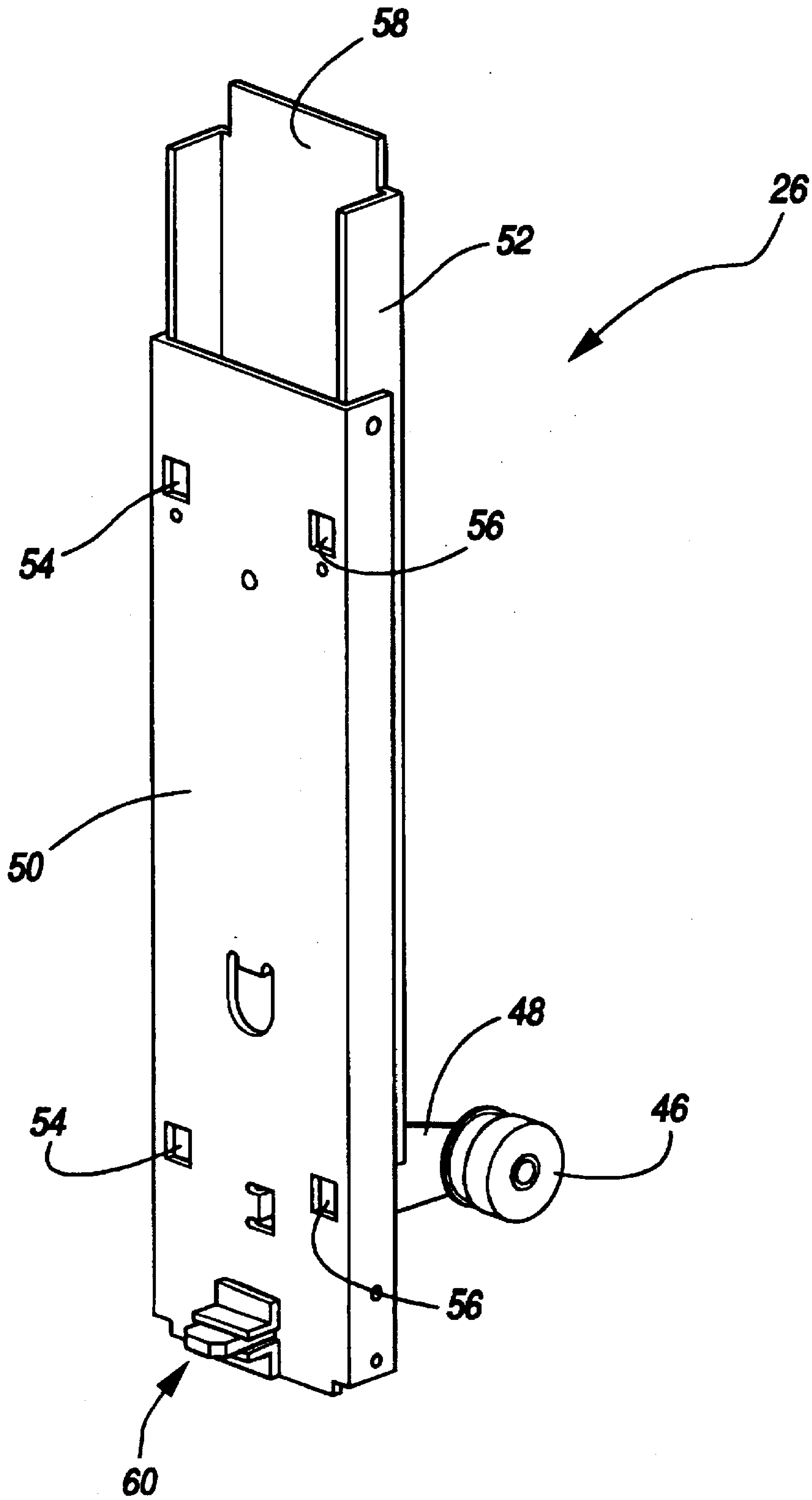


FIG. 4

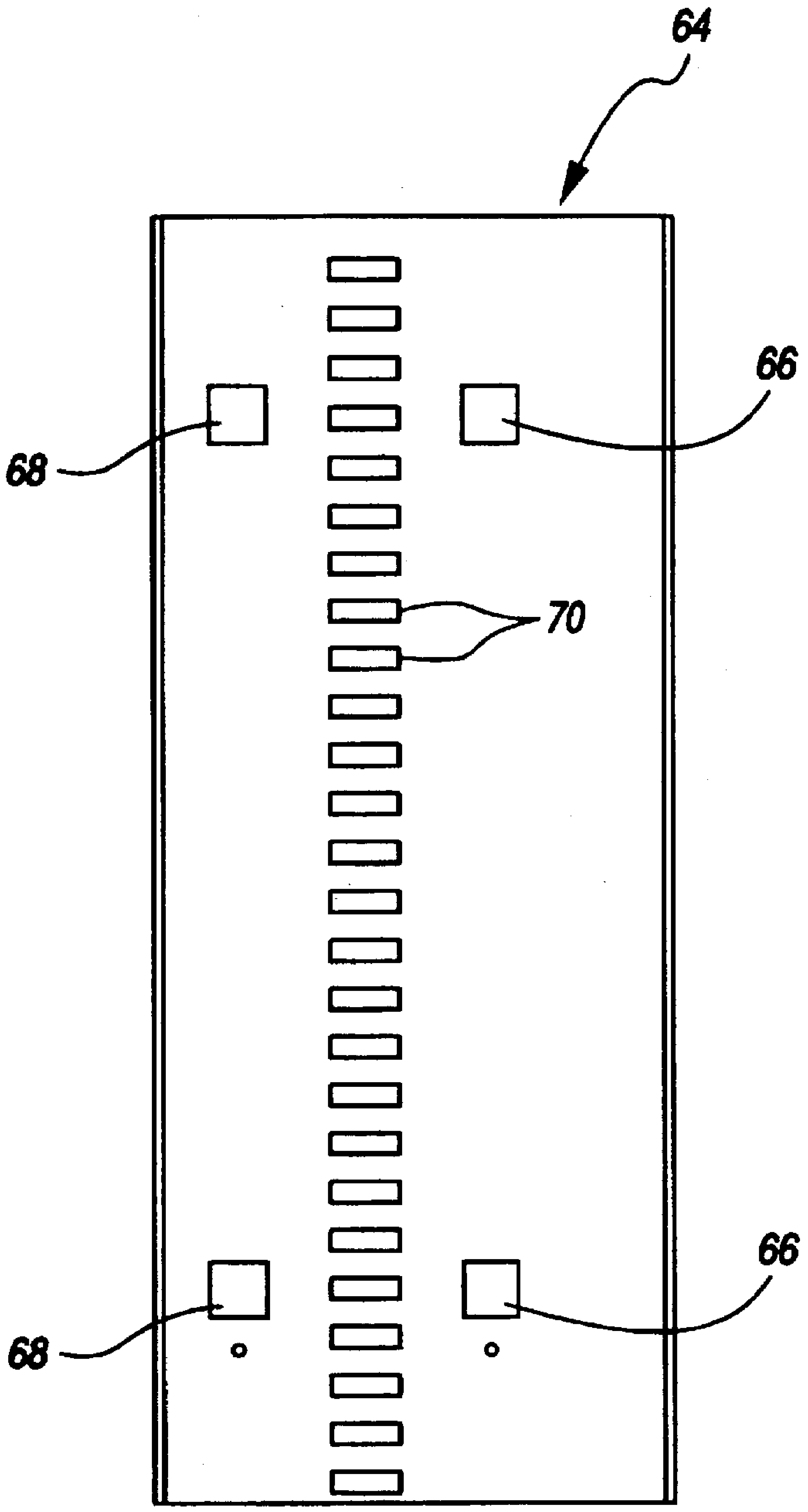


FIG. 5

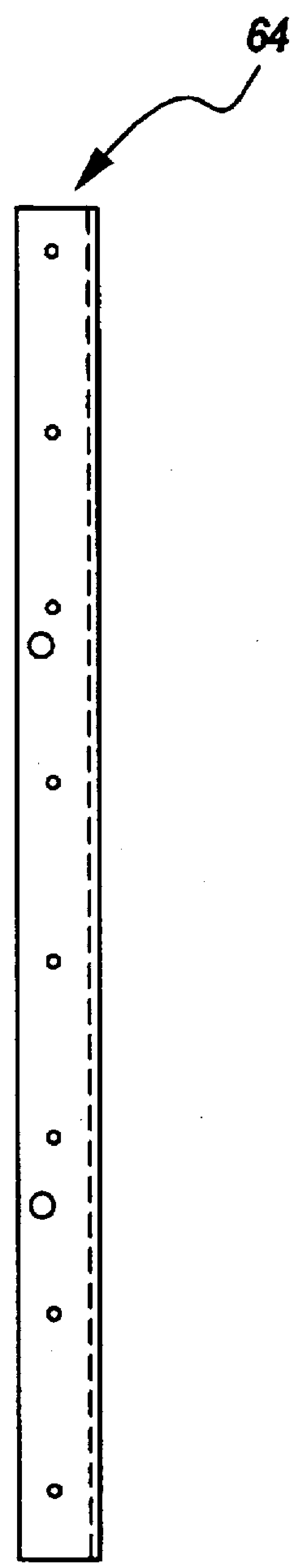


FIG. 6

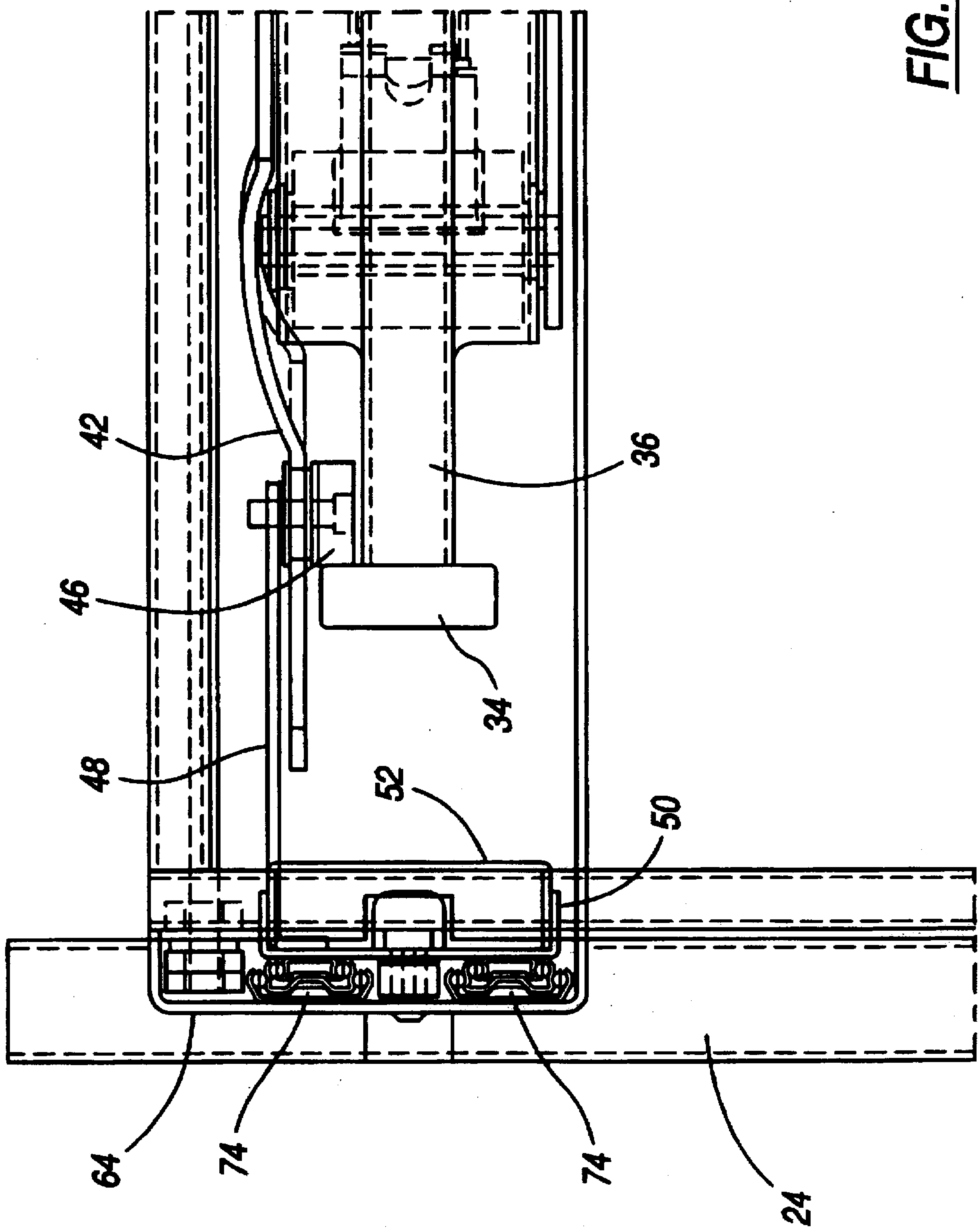


FIG. 7

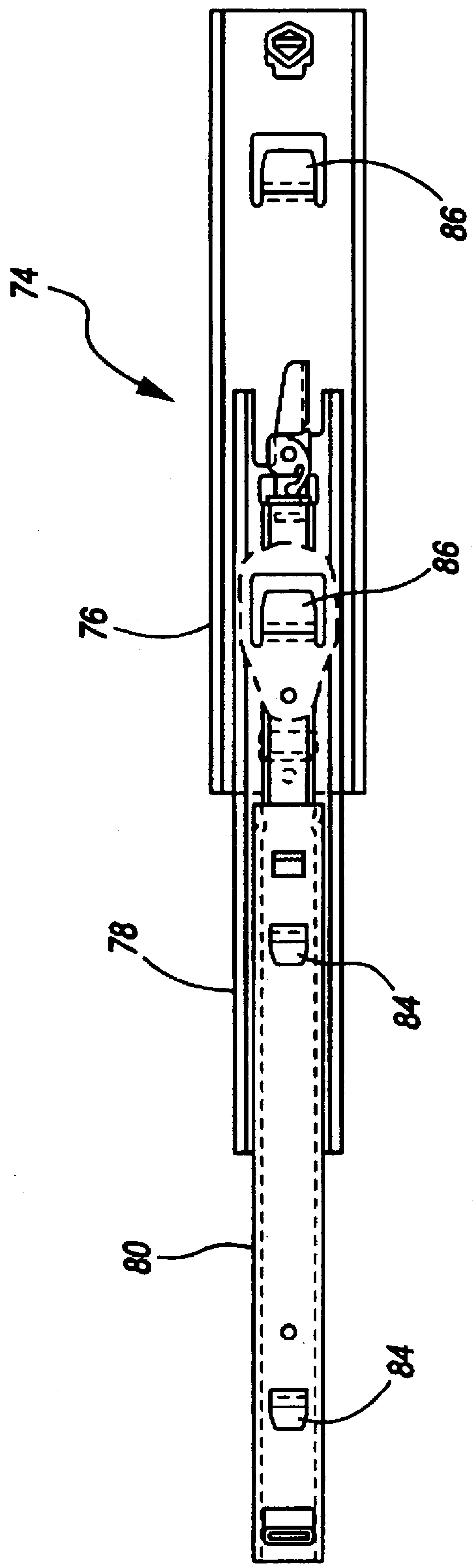


FIG. 8

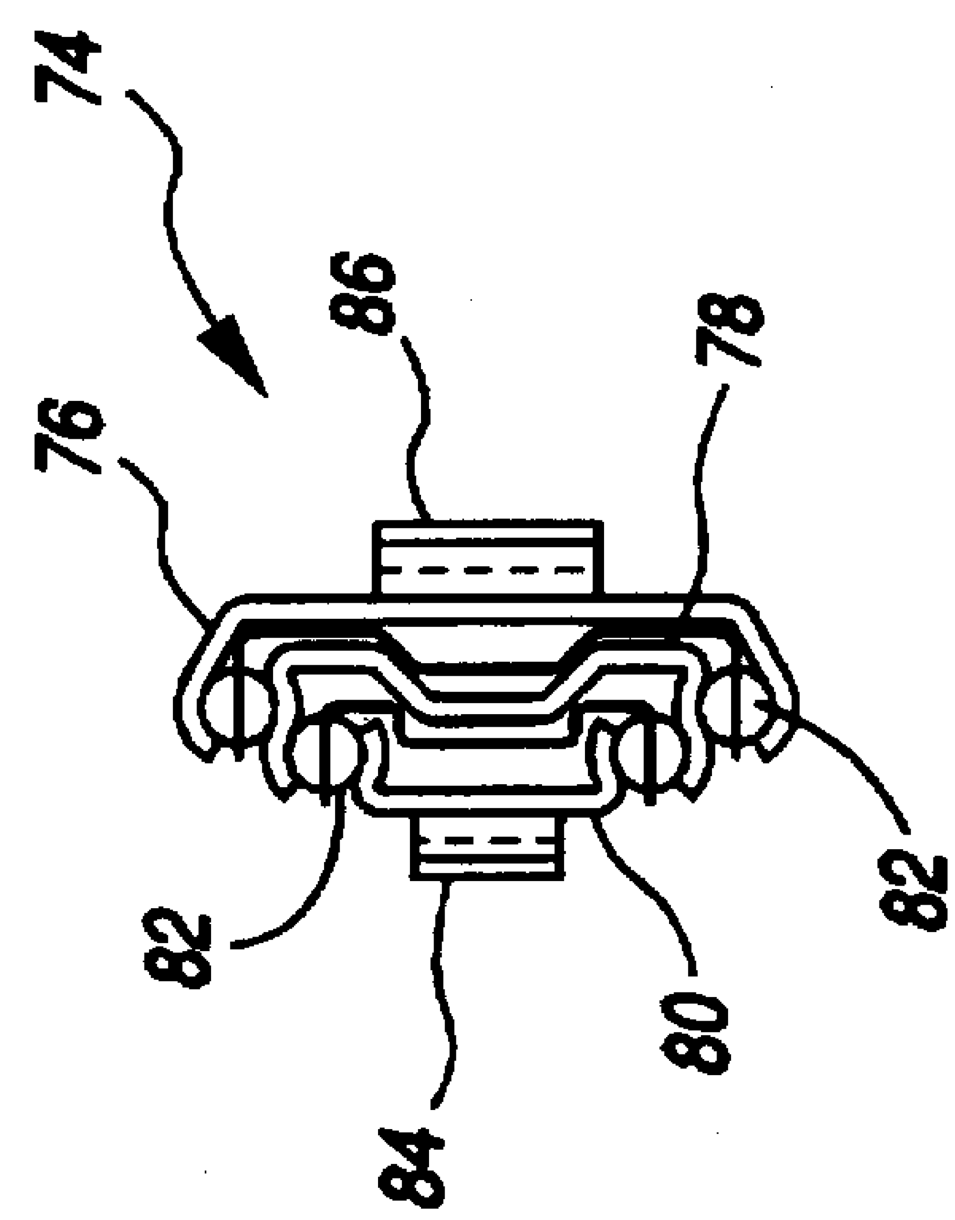


FIG. 9

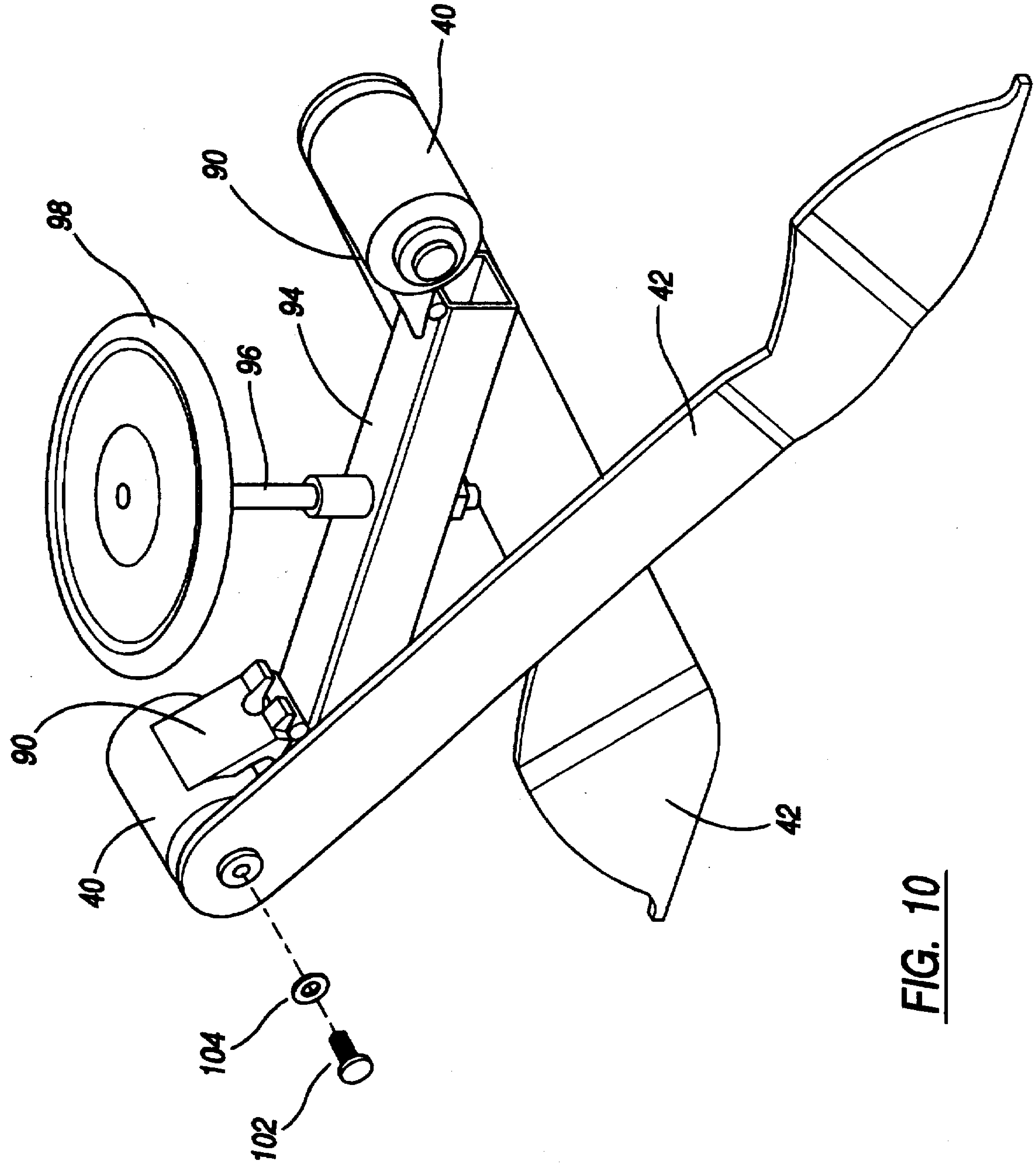


FIG. 10

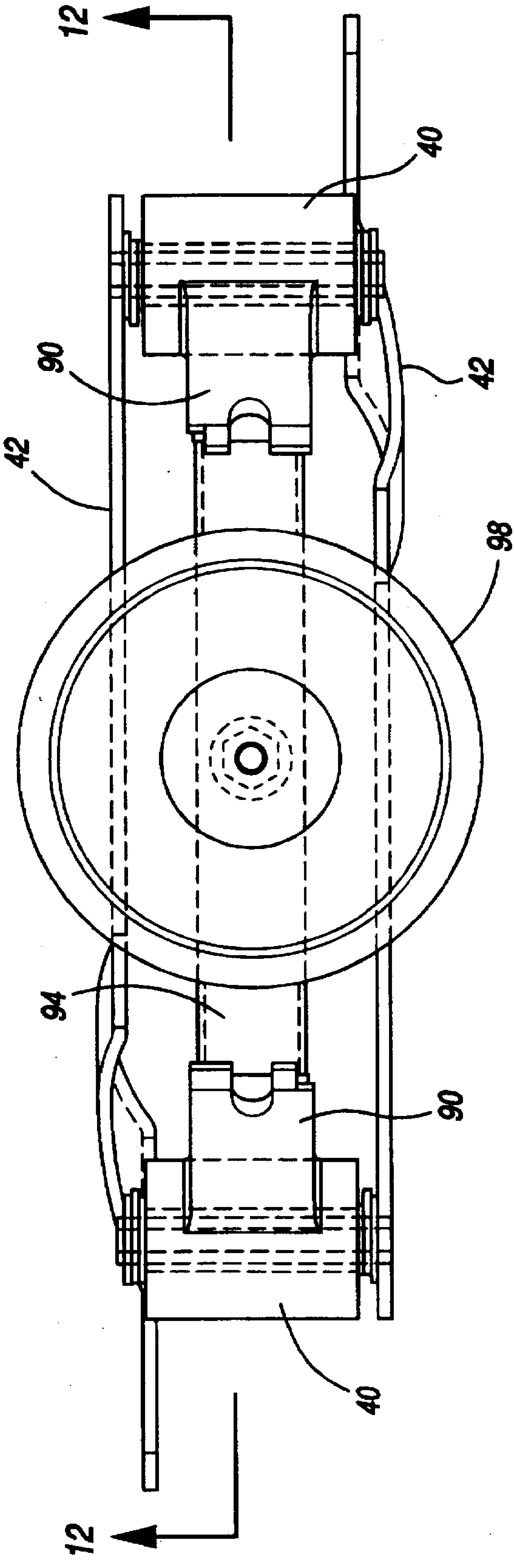
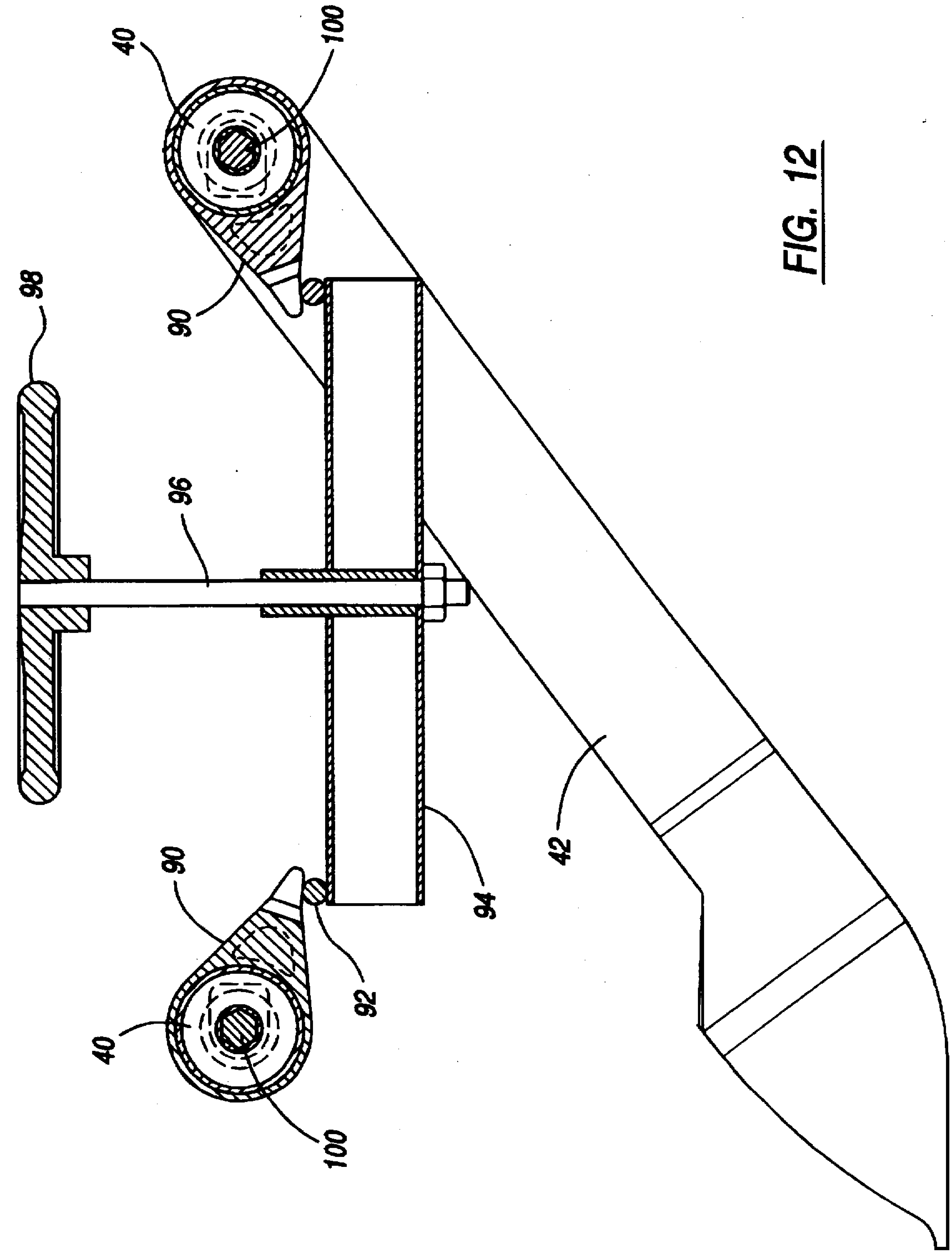


FIG. 11



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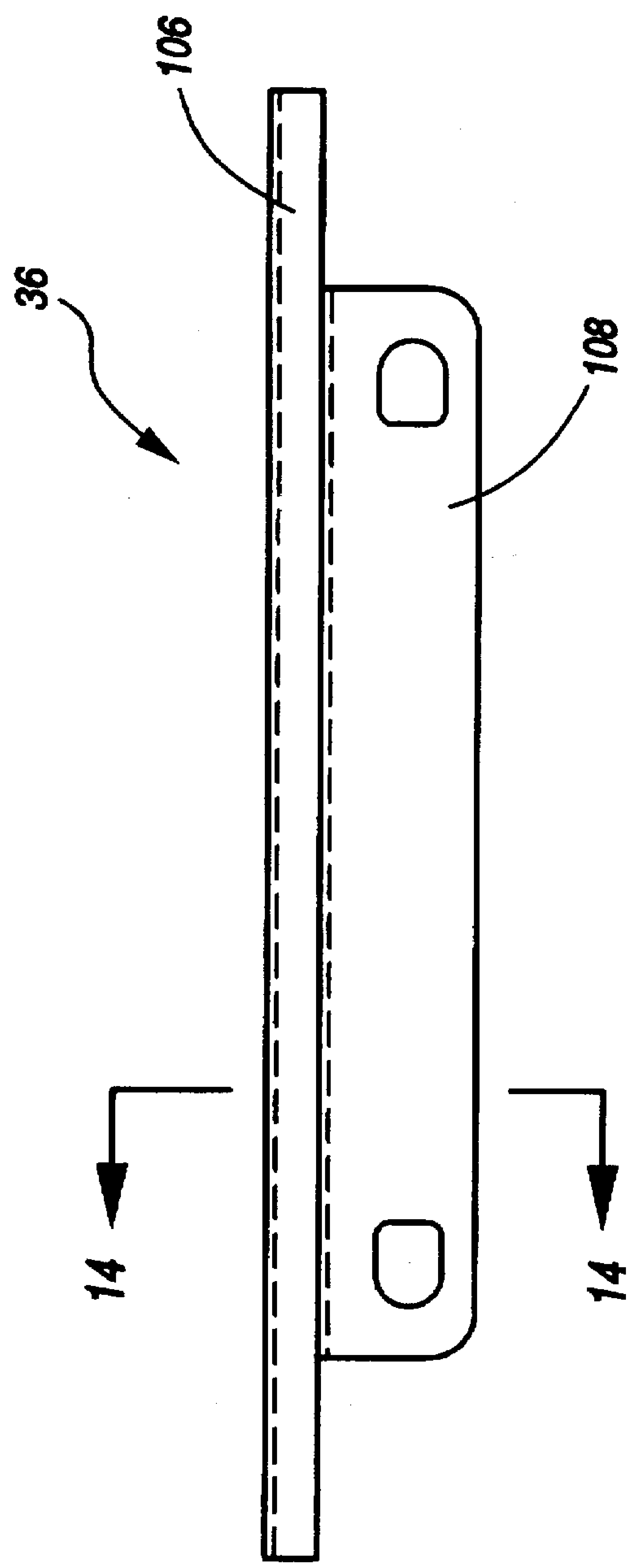

FIG. 13

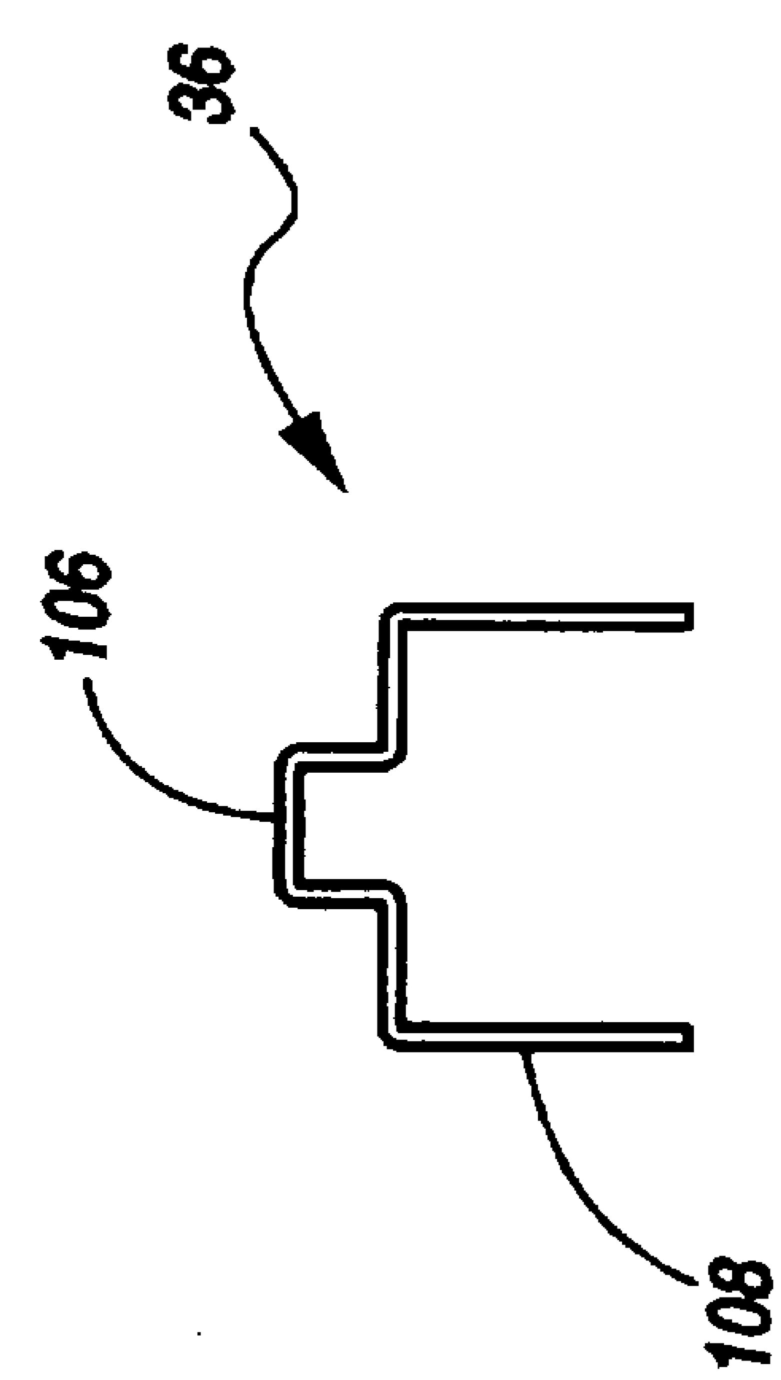

FIG. 14

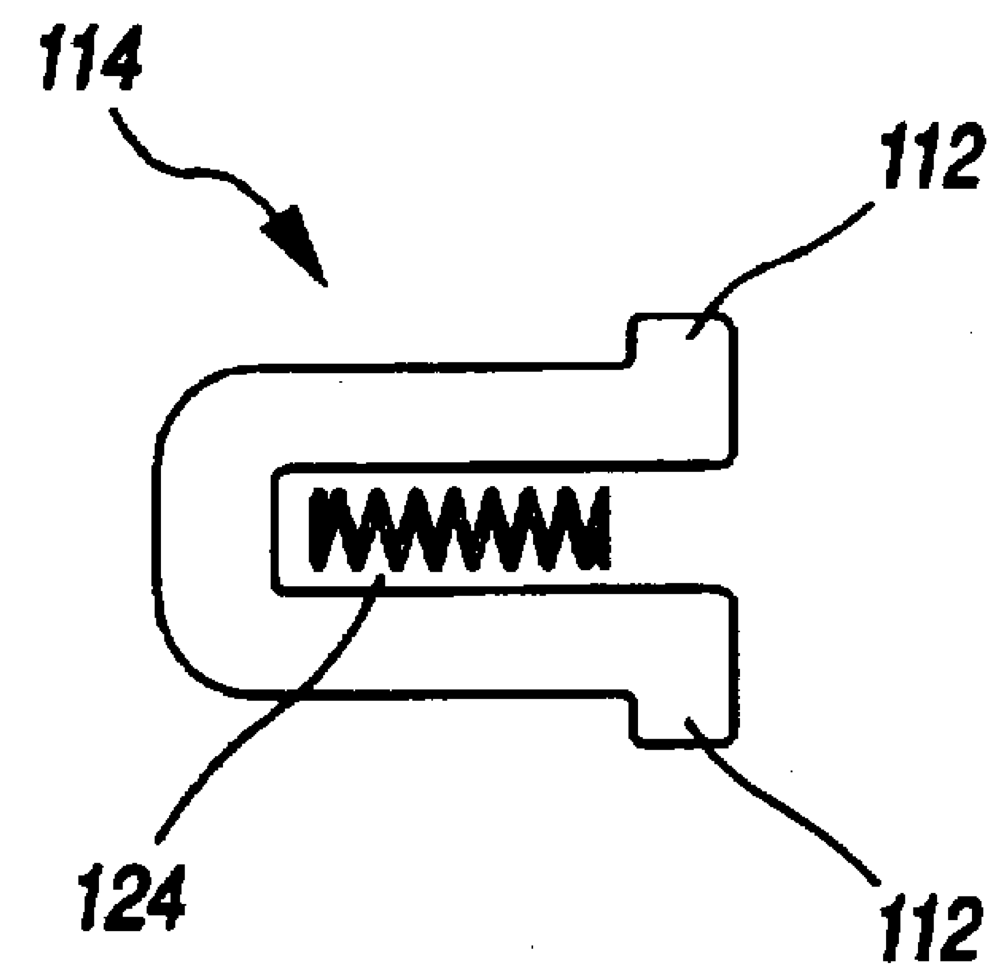

FIG. 17

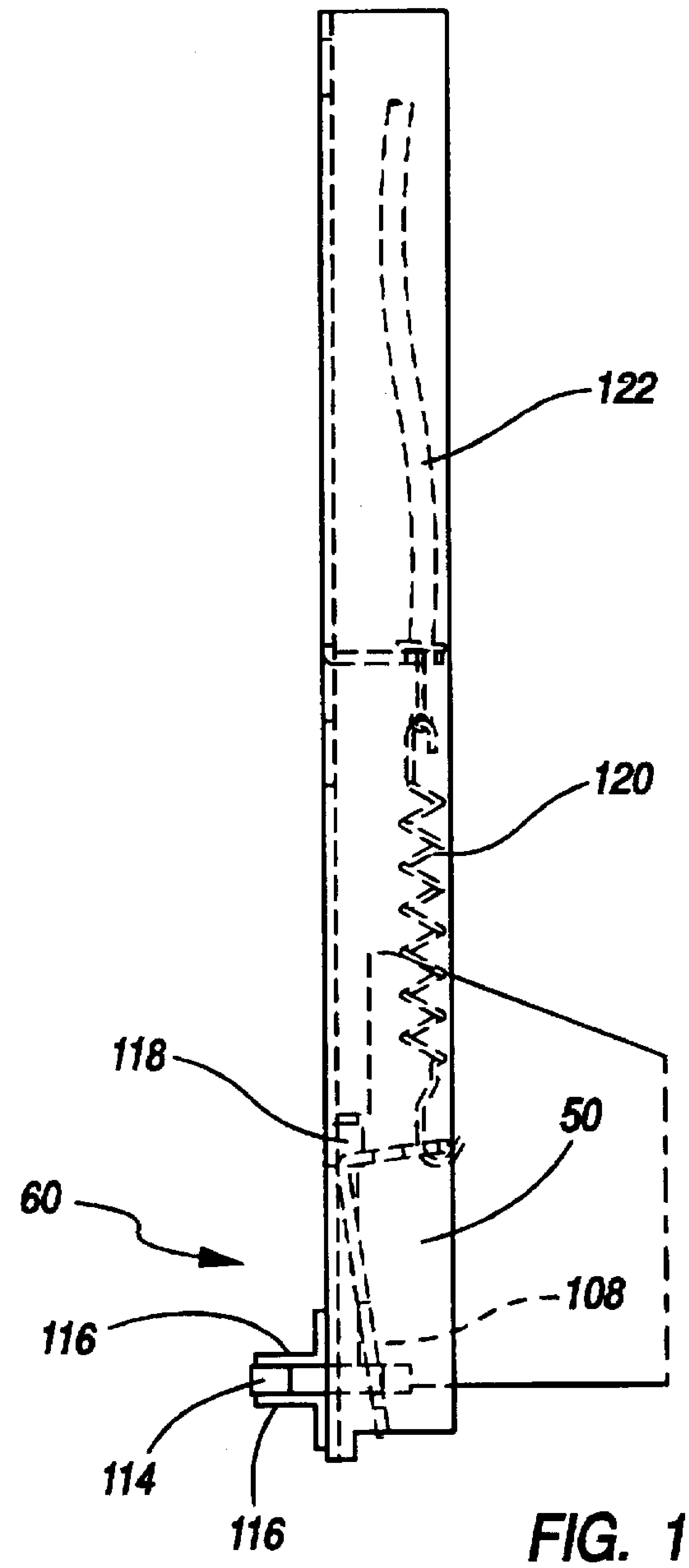

FIG. 16

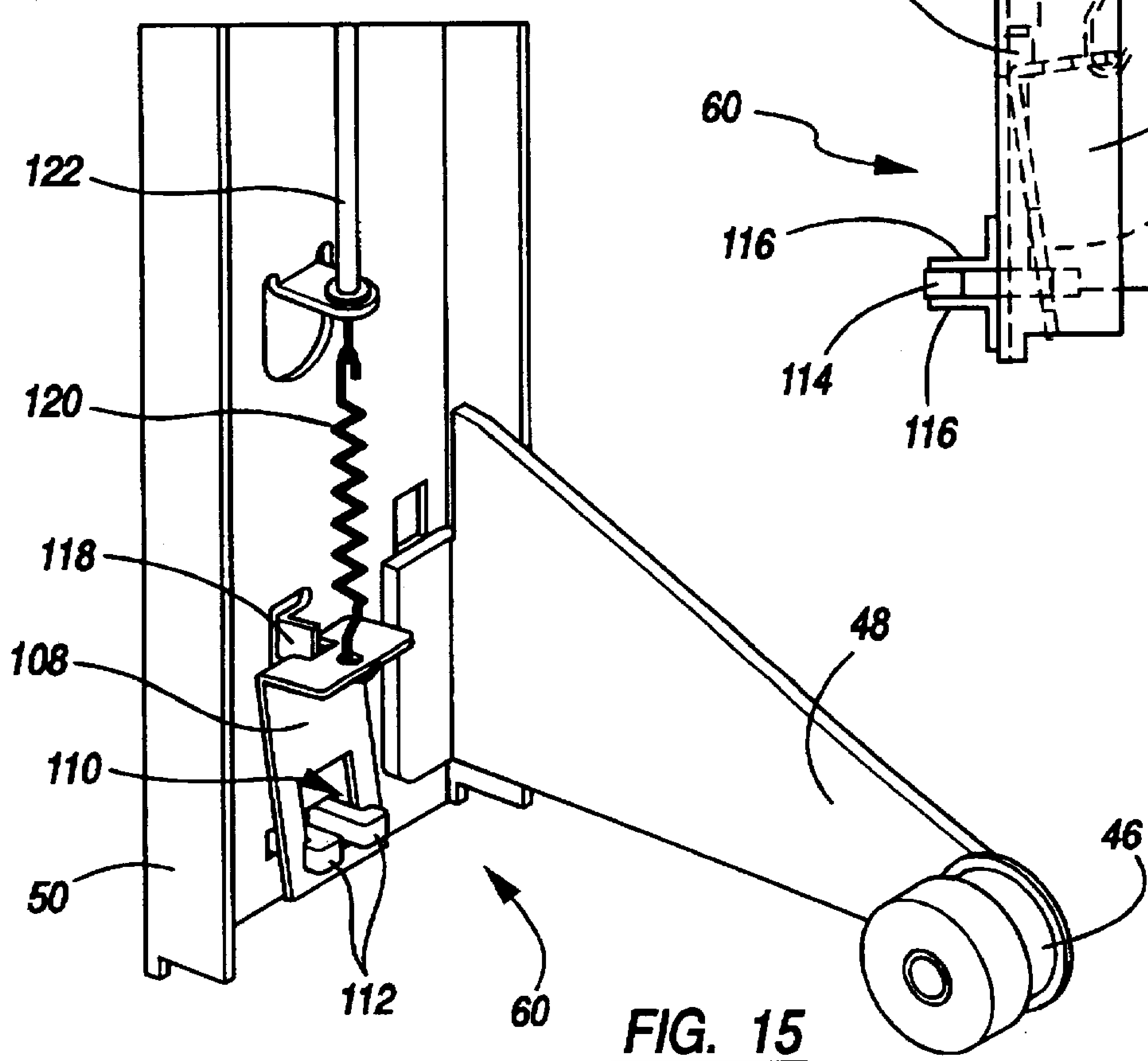

FIG. 15

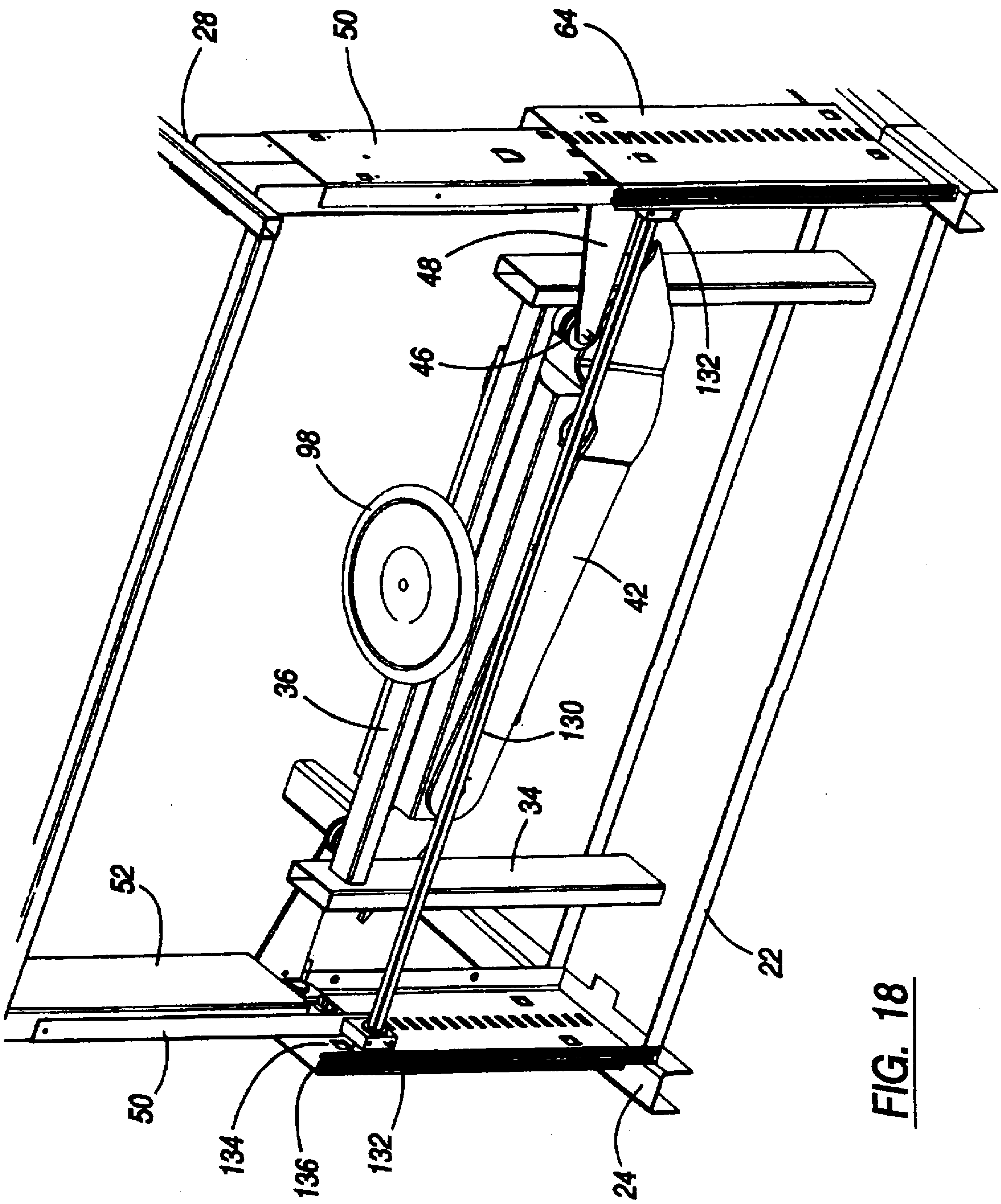

FIG. 18

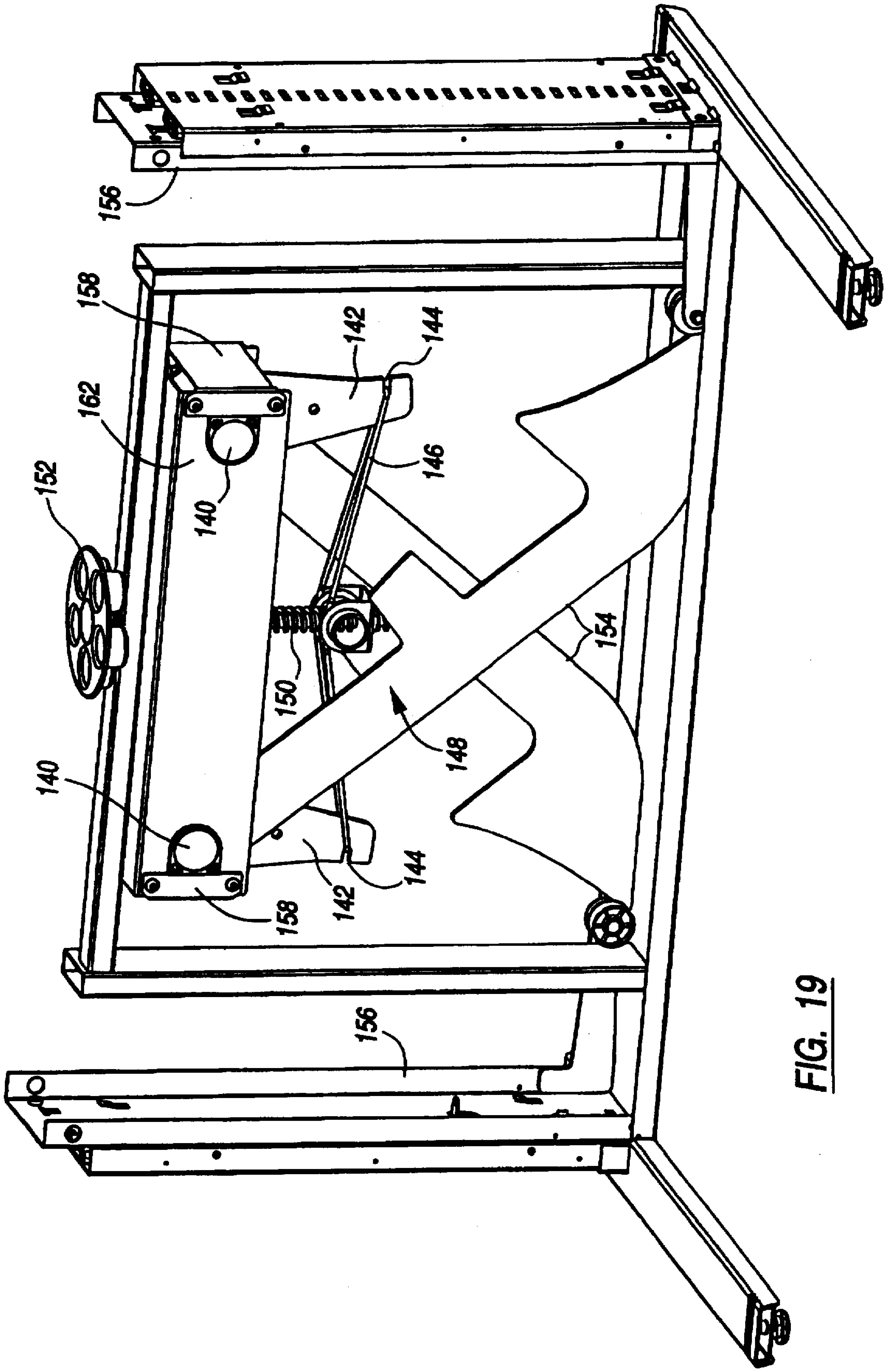

FIG. 19

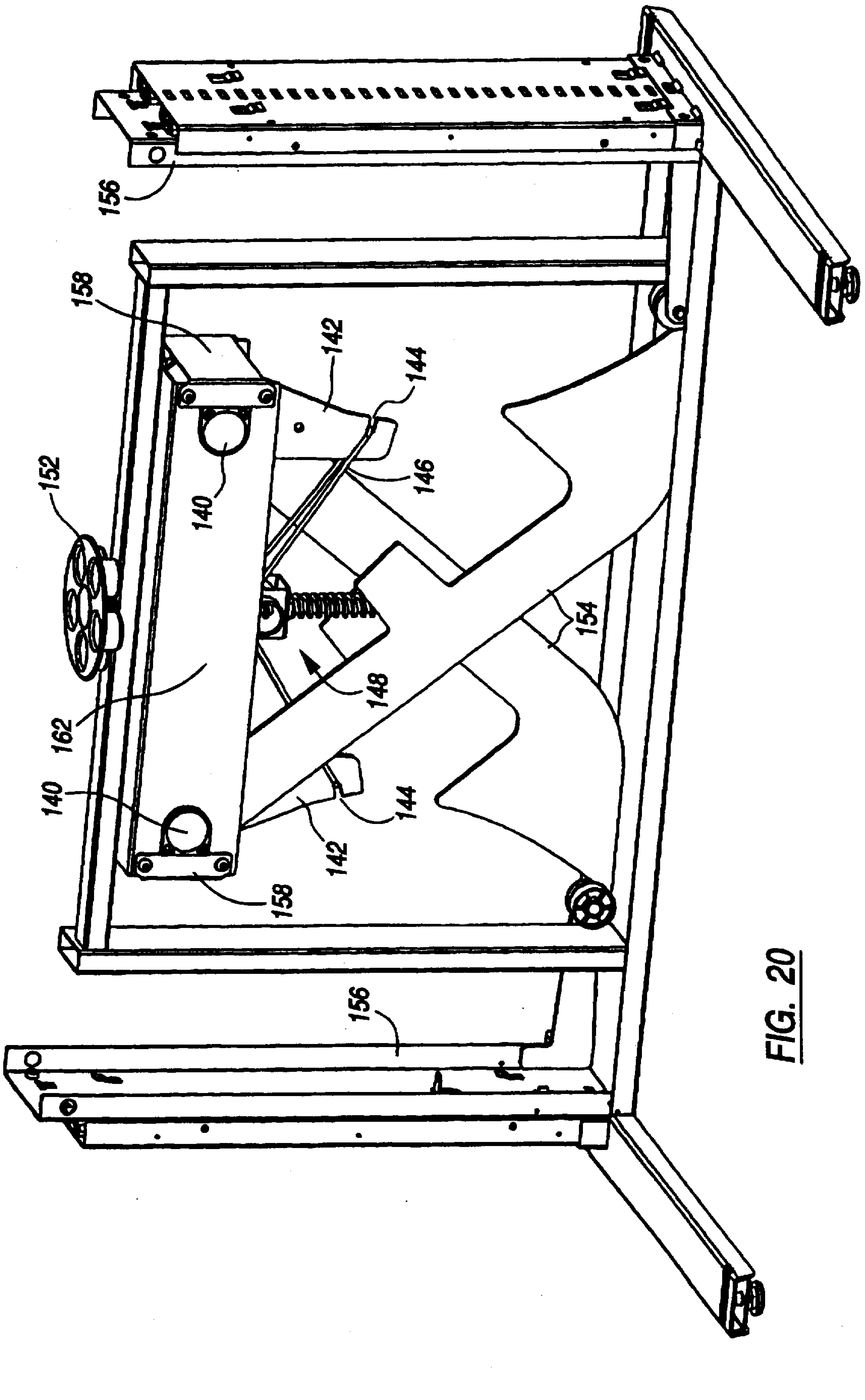

FIG. 20

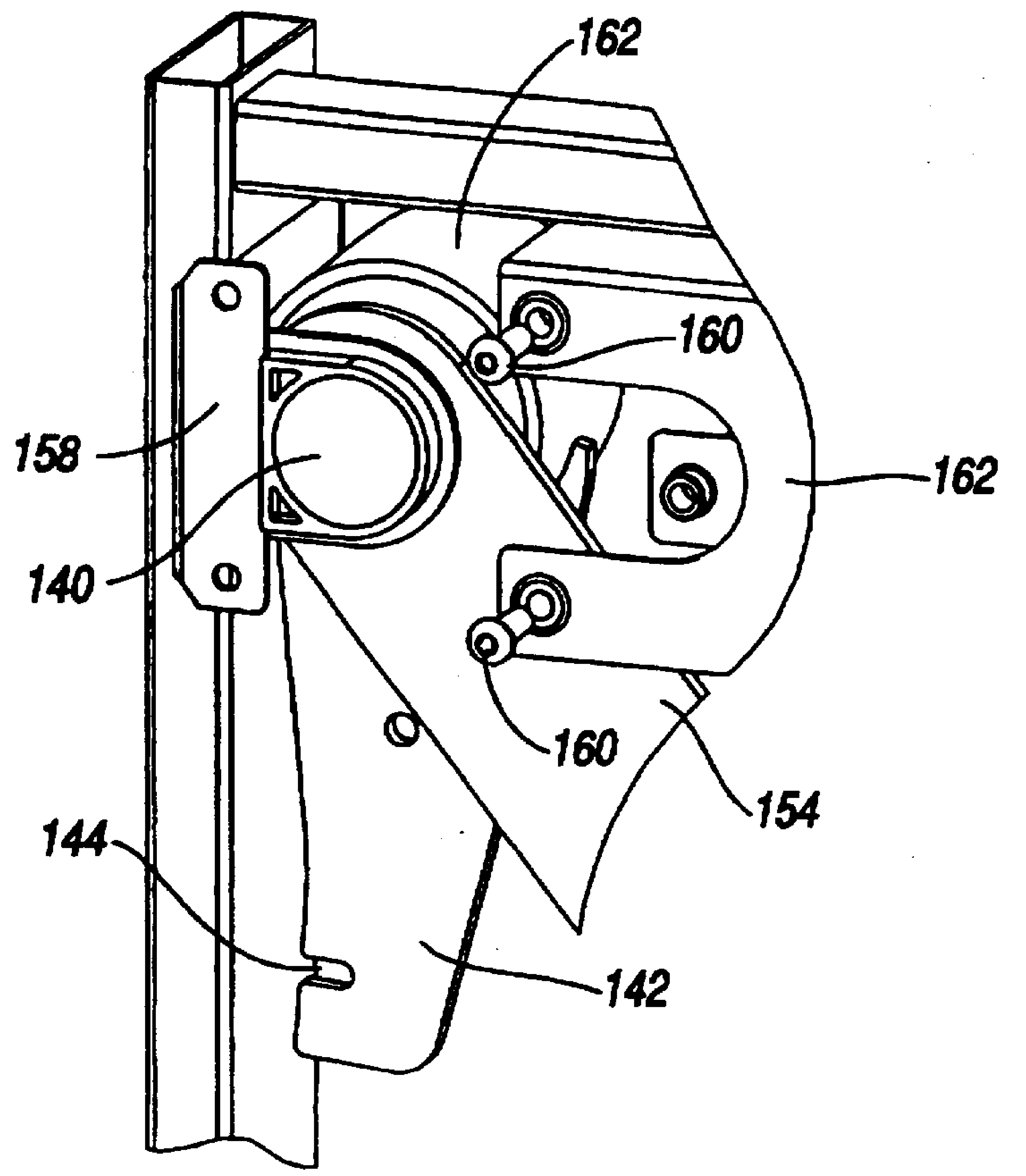

FIG. 21

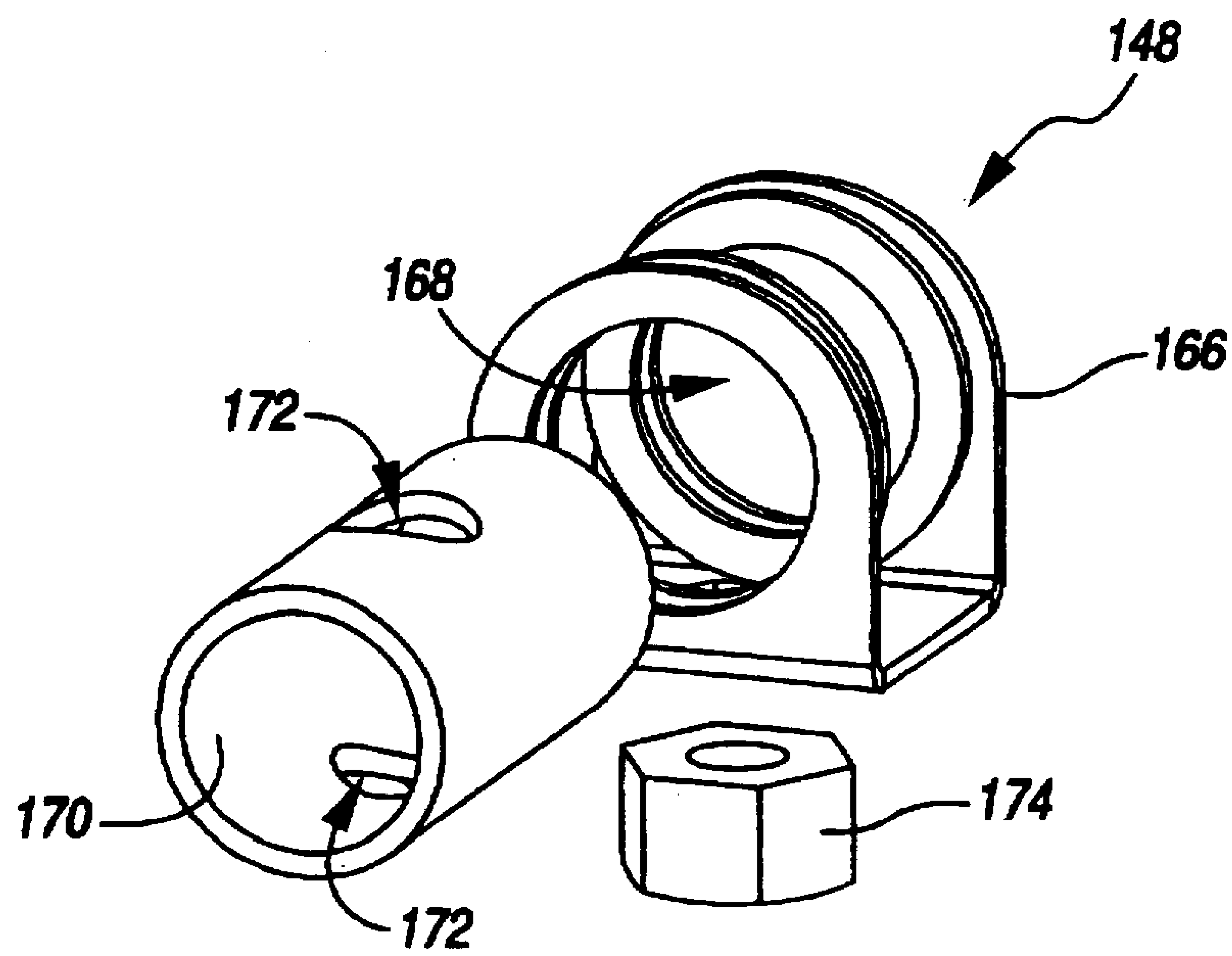

FIG. 22

ADJUSTABLE HEIGHT LOAD BEARING SUPPORT STRUCTURE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of commonly owned co-pending U.S. Patent application Ser. No. 08/634,592, filed Apr. 18, 1996, and titled "Adjustable Height Load Bearing Support Structure."

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a load bearing support which is adjustable in height and, more particularly, to a load bearing member which is counterbalanced in a manner such that it can be adjusted to an equilibrium condition for a specific load placed on it whereby the load may be raised or lowered as though weightless through its entire vertical path of travel.

2. Description of the Prior Art

In many applications it is desirable to support a load of some type such that the load may be conveniently raised or lowered. In the contemporary design of office environments, for example, it has been found desirable to sometimes provide tables or desks having work surfaces which are height adjustable. In fact, increasing numbers of people who work in office environments prefer to alter the height of their desk surfaces from a level at which they can be seated in a chair to a level at which they can work while standing. Such height adjustability allows the worker to vary his or her body position and avoid fatigue associated with being confined to a single posture over an extended period of time.

Increasingly, more and more office workers use computers in the course of their normal duties and have their computers placed on their desks. Particularly if the computer monitor and central processing unit are placed on the desk, these items can add considerable weight to the desk surface. Thus, where the desk surface is height adjustable, it is essential that some means be provided for counterbalancing the desk surface so that the user does not need to exert the considerable force which would be needed to raise the desk work surface and associated equipment.

Many systems are known for counterbalancing height adjustable support structures. Early forms of such systems may be found in the drafting table art wherein it is often desirable to have a height adjustable drawing surface. Drafting tables are known, for example, which use forms of parallelogram linkage mechanisms or cable and pulley arrangements and wherein extension springs are used to counterbalance the work surface. However, these arrangements are typically not adjustable in any way to compensate for added weight placed on the work surface. Hence, they are generally unsuitable for use in a height adjustable desk capable of supporting the added weight of a computer or other office equipment. Moreover, they would not provide for counterbalanced work surface support over the full range of vertical adjustment of the surface because the force of the counterbalancing springs changes significantly as the springs are extended.

Attempts have been made to design height adjustable load support members which are counterbalanced in a manner as to also be adjustable to balance differing loads placed on the support surface. One such example of an adjustable load supporting device is disclosed in Holmquist, U.S. Pat. No. 5,236,171, issued Aug. 17, 1993. In that patent, a linkage system is disclosed which is connected to a gas spring. The spring has its opposed ends adjustable along linkage members to exert greater or lesser force on a work surface support member thereby compensating for the load on the associated support surface. However, a disadvantage of that device is that both ends of the spring must be adjusted to compensate for different loads. Moreover, in practice, two such gas springs must be employed, one for each side of the support surface. Thus, when this device is used as a height adjustable desk for example, four separate adjustments must be made if greater or lesser load is placed on the work surface and the load is to be effectively counterbalanced. Moreover, it is not self explanatory how such four adjustments should be made for any given load condition. Thus, as a practical matter, this arrangement is undesirable for use as a consumer product in which relative simplicity of operation is preferred.

In co-pending application Ser. No. 08/634,592, a height adjustable load bearing support structure is provided which may be used as a table or desk. The structure, as will be described hereinafter in detail, includes two extendable vertical support assemblies for supporting a work surface for vertical movement relative to a base frame. Each support assembly is engaged by a spring biased pivotable arm to counterbalance the weight placed on the work surface. A cam system cooperating between the distal ends of the pivotable arms and the support assemblies serves to compensate for the changing spring force on the arms by varying the effective moment arms of the arms thereby equalizing the force on each support assembly through its complete range of vertical travel. This construction has proved to be most advantageous in providing a height adjustable support surface, such as a table or desk top, which may be adjusted to compensate for the load of equipment placed on the surface whereby the equipment and surface are counterbalanced through a range of vertical travel. The user may thereby adjust the support surface between a low position, such as that of standard desk top, to an elevated position without manual exertion.

In the aforesaid construction, the spring biasing force of the pivotable arms is adjustable to compensate for loads of differing gravitational force. The adjustment is accomplished by a vertically movable tube member which engages arms secured to the housings of each torsion spring. In this connection, a preferred spring for biasing the arms is an elastomeric torsion spring with a cylindrical housing. The tube member is vertically adjustable as to preload the springs to a desired upward force on the pivotable arms. A screw arrangement is used to adjust the tube member vertically. However, it has been discovered that frictional forces between the tube member and the arms of the torsion spring assemblies can cause unevenness in the relative preloading of the two torsion springs. This uneven preloading translates to differential upward force on the respective pivotable arms which can cause binding or racking of the work surface support members as the position of the support surface is changed.

Accordingly, it is desirable to provide an improved adjustment mechanism for preadjusting the upward force on a load bearing support surface of the type disclosed in the aforementioned application for patent. In particular it is desirable to provide an improved adjustment mechanism which minimizes binding or racking of the support surface as its position is changed through a vertical path of travel.

SUMMARY OF THE INVENTION

The present invention is an improvement in adjustable height load bearing support structures by providing a pretensioning mechanism for a support surface structure which comprises a pair of pivotable arms each having a free end in engagement with a support assembly and being biased by a torsion spring. A lever arm is connected to each torsion spring and exerts a biasing force on the pivotable arm when the lever is rotated, thereby preloading the springs. A cable connects the lever arms and passes over a central bushing. The bushing receives a threaded shaft which may be turned to move the bushing and thereby adjust the tension in the cable. Because the cable is capable of sliding engagement with the bushing, tension in the cable is substantially uniform throughout its length and thus the resultant forces on the lever arms is approximately equal. Correspondingly, the forces on the two pivotable arms and associated support assemblies is approximately equal, whereby binding or racking of the support assemblies is minimized as the support surface is raised or lowered.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other novel features and advantages of the invention will be better understood upon a reading of the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a front elevational view of a first embodiment of a table constructed in accordance with the principles of the invention;

FIG. **2** is a top plan view thereof;

FIG. **3** is a right side elevational view thereof;

FIG. **4** is a perspective view of work surface support assembly constructed according to the principles of the invention;

FIG. **5** is a front view of a channel member for cooperation with the work surface support assembly;

FIG. **6** is a side view thereof;

FIG. **7** is a partial top view illustrating the component parts of the work surface support assembly;

FIG. **8** is a plan view of a slide assembly for supporting the work surface of the table;

FIG. **9** is an end view thereof;

FIG. **10** is a perspective view illustrating the counterbalancing mechanism of the table;

FIG. **11** is a top plan view of the counterbalancing mechanism;

FIG. **12** is a cross-sectional view taken substantially along the line **12**—**12** of FIG. **11**;

FIG. **13** is a side view of a support channel for supporting the counterbalancing mechanism;

FIG. **14** is a cross-sectional view taken substantially along the line **12**—**12** of FIG. **13**;

FIG. **15** is a partial perspective view illustrating the latch mechanism of the present invention;

FIG. **16** is a side view thereof;

FIG. **17** is a plan view of a latch bar as used in the latch mechanism;

FIG. **18** is a rear perspective view of a table in accordance with the invention illustrating the work surface elevated to its uppermost position;

FIG. **19** is a front perspective view of a second embodiment of a table constructed in accordance with the principles of the present invention illustrating a modified spring pretensioning system over the system disclosed in the previous drawing figures and showing the springs as pretensioned to a first counterbalancing force;

FIG. **20** is a front perspective view of the modified support structure illustrating the springs as pretensioned to a second counterbalancing force;

FIG. **21** is a partial exploded perspective view of the spring mounting construction; and

FIG. **22** is an exploded perspective view of a portion of the spring pretensioning assembly.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the present invention will be described hereinafter in the context of an adjustable height table for office use, it will be appreciated that the invention is equally applicable to load bearing structures of many different types useable in a variety of different applications.

Referring now to the drawings, and initially to FIGS. **1**–**3**, an adjustable height table is designated generally by the reference numeral **20** and includes a base frame **22** including a pair of opposed legs **24**. Supported on the frame **22** are a pair of extendable upright support assemblies **26** which will be described in detail hereinafter. At the upper ends of each assembly **26** a forwardly extending arm **28** is provided. The arms **28** are connected by a cross brace **30** which together serve to support a suitable work surface **32**.

Positioned beneath the work surface **32** and attached to the base frame **22** as by welding is a support structure comprising two vertical tubes **34** and a connecting cross brace **36**. The cross brace **36** supports a pair of elastomer torsion springs **40** each connected to a generally elongate arm **42** which extends diagonally beneath the work surface **32**. The distal end of each arm is provided with a cam surface **44** on which a roller **46** rides. The rollers **46** are journaled for free rotation on brackets **48** connected to the upright assemblies **26** as will be described hereinafter. The rollers **46** have dual roller surfaces, one of which rides on the cam surface **44** and the other of which rides on the vertical tubes **34**. In this way the vertical tubes **34** resist lateral forces placed on the brackets **48** as the rollers **46** ride on the cam surfaces **44**.

The construction of the upright assemblies **26** can be seen in FIG. **4**. Each assembly **26** includes two C-shaped channel members **50** and **52** preferably bolted together with member **52** slidingly received within member **50**. This sliding configuration allows the assembly **26** to be manually adjusted for differing ultimate heights of the work surface **32**. The roller bracket **48** is preferably welded to the inside of the channel member **50**. The channel member **50** is provided with pairs of spaced rectangular apertures **54** and **56** for receiving lanced tabs of ball bearing slide assemblies as will be hereinafter described. The upper end of member **52** is provided with a flange **58** to which each arm **28** is welded. A latch assembly **60** as will be described is provided at the lower end of the member **50**. The assemblies **26** further include a generally C-shaped channel member **64** which is preferably welded to legs **24** of the base frame **22**. As best seen in FIGS. **5** and **6**, these channel members **64** include pairs of spaced rectangular apertures **66** and **68** and a series of aligned closely spaced slots **70**.

The assembled condition of the uprights **26** is best seen in the top view of FIG. **7** wherein a pair of ball bearing slide assemblies **74** are disposed between the channel member **64** and the member **50**. Each slide assembly **74** may be of a type well known in the art for use in cabinetry, and best seen in FIGS. **8** and **9**, consisting of three track members **76**, **78** and **80** which freely slide on suitable ball bearings **82**. The innermost track **80** is provided with lanced tabs **84** which engage the aforementioned apertures **54** and **56** of the channel member **50**. Likewise, the outermost track **76** is provided with lanced tabs **86** which engage the apertures **66** and **68** of the channel members **64**. By this arrangement, pairs of slide assemblies **74** may be readily installed in the upright assemblies **26** and secured in proper place by suitable sheet metal screws.

The function of the arms **42** in counterbalancing the work surface **32** can best be seen in FIGS. **10**, **11** and **12**. The elastomeric springs **40** are provided with arms **90** extending from one side thereof which are each engaged by bearing rods **92** welded to a cross tube **94**. A threaded shaft **96** connected to a hand wheel **98** may be manually turned to increase or decrease the tension of the two spring **40** thereby altering the spring force on the counterbalancing arms **42**. The connection between the arms **42** and springs **40** is preferably made by hexagonal cross-section shafts **100** to which the arms **42** are fastened by suitable screws **102** and associated washers **104**. The cross brace **36** which supports the springs **40** and the associated tension adjustment members is shown in FIGS. **13** and **14** and can be seen to be an integrally stamped and formed member having a first narrow channel portion **106** and a wide lower channel portion **108**.

An important feature of the invention is the latch assembly **60** best illustrated in FIGS. **15–17**. The latch assembly **60** includes an L-shaped bracket **108** having an aperture **110** which engages ears **112** of a latch bar **114**. The ears **112** each project through an aperture of the channel member **50** and the bar **114** is guided by a pair of L-shaped supports **116** extending from the outwardly directed side of the channel member **50**. A tab **118** struck from the channel member **50** is received by a slot formed in the bracket **108** permitting the bracket **108** to rock under the action of a suitable spring **120** and associated cable **122**. The latch bar **114** is normally biased outwardly by a spring **124** which bears against the channel member **50**. When the cable is relaxed, the latch bar **114** will project outwardly of the supports **116** a sufficient distance to engage a selected slot **70** of the channel member **64**. The work surface **32** may thereby be effectively locked in a plurality of vertical positions relative to the floor of the surrounding room.

Operation of the table **20** can best be seen in the perspective view of FIG. **18**. In this view the table **20** is shown in a fully upwardly extended position. The slide assemblies **74** are removed for clarity. In this position, the arms **42** have biased the support assemblies **26** upwardly directed force on the brackets **48**. The rollers **46** have followed the cam surfaces **44** of the arms **42** to a position closer to the pivot shafts **100** of the arms **42**. Thus, as the torsion springs **40** unwind and exert lesser force on the arms **42** the effective moment arm of each arm **42** is reduced causing the resultant force on the brackets **48** to be equalized throughout the range of vertical travel of the work surface **32**. As weight is placed on the work surface **32**, such as computer equipment or the like, the spring **40** force may be increased by turning the hand wheel **98** and tensioning the springs **40** to any desired condition. Thereby, the work surface **32** may be counterbalanced for a variety of loads placed thereon such that it can be raised or lowered as desired by the table **20** user with relative ease once the springs **40** are preadjusted for the weight of the load.

It can be appreciated that loads placed on the work surface **32** may be off-center of the work surface. Thus, to accommodate uneven loading of the work surface **32** and permit both support assemblies **26** to raise and lower at the same rate and without binding a system may be employed such as rack and pinion gearing to synchronize movement of the support assemblies **26**. As shown in FIG. **18** such a system may include a shaft **130** supported on the channels **50** by suitable bearings **132** and having spur gears **134** which engage vertical gear racks **136** mounted to the channels **64**. Such a system will assure that both support assemblies **26** move evenly at the same rate despite off-center loading.

In constructing the counterbalance assembly it has been found through experimentation that the cam surfaces **44** of the arms **42** are preferably formed with a radius of curvature located in the direction of the base frame **22** of the table **20**. The combination of the changing cam surface **44** angle and the changing moment arm result in a constant vertical component of force acting on the roller **46**. By this arrangement the vertical component of force on the brackets **48**, as compensated for a degree of lateral frictional force, will be very closely equalized through the entire range of vertical movement of the work surface **32**, making it almost effortless to raise or lower the table height. A suitable elastomeric torsion spring **40** which performs well with the table **20** is available from Lord Corporation of Erie, Pa. However, a steel torsion spring will perform equally well. It can also be appreciated that the cable system **122** used to operate the latch **60** may be constructed to be either hand operated or foot operated. In one form of the invention the cable **122** from both sides of the table may be routed to a Y-connection beneath the work surface **32** as to be hand-operated by a suitable know (not shown).

An advantage of the invention is that the table **20** may be assembled with differing ranges of vertical height capability depending on the preferences of the user. This is possible simply by bolting the channel members **50** and **52** together at differing telescoping position. With the slide assembly **74** illustrated, the table may have a work surface height adjustment range from as low as 26 inches to 44 inches to greater than 30 inches to 48 inches. It is also important that the entire counterbalancing mechanism is located underneath the work surface **32** and toward the rear of the table **20**. This distinguishes over tables having counterbalancing mechanisms located on the sides of the table which must be shrouded to avoid safety hazards and thus have an awkward appearance. The mechanism of the present table **20** may be shrouded to appear like a modesty panel which is a common feature of many expensive looking tables and desks.

Turning now to FIG. **19**, a front perspective view is shown of an adjustable height load bearing support structure constructed in accordance with the principles of the present invention illustrating a modified spring tensioning system over the system shown in FIGS. **10**, **11** and **12**. In this tensioning system, torsion springs **140** preferably of an elastomeric type are provided with downwardly extending arms **142** having slots **144** for receiving a transverse cable **146**. The cable **146** runs between the two arms **142** and across a cable tensioning mechanism designated generally as **148**. A screw shaft **150** operated by a hand wheel **152** is threaded to the mechanism **148** and draws the cable **146** up or down at its center placing greater or lesser force, respectively, on the arms **142**. In this manner, the springs **140** can be pretensioned through a range of tension force on pivotable arms **154** which, in turn, pretensions the upward forces on support members **156**. FIG. **19** shows the tensioning system in a somewhat relaxed condition while FIG. **20** shows the system in a relatively tightly tensioned condition.

FIG. **21** shows the details of the spring **140** mounting structure wherein the spring is supported by a suitable bracket **158** fastened by screws **160** to a main cross housing **162**. The arms **142** may be secured as by welding to outer housings **162** of the springs **40**.

FIG. 22 illustrates the principal elements of the tensioning mechanism **148** which include a generally U-shaped bracket **166** having circular openings **168** for slidingly receiving a bushing **170**. The bushing **170** is provided with a pair of aligned apertures **172** for slidingly receiving the screw shaft **150** which, in turn, is threaded into a nut **174** secured to the bracket **166**.

It can now be appreciated that the pretensioning adjustment system of the present invention offers considerable advantages in permitting ease of raising and lowering of an adjustable height support assembly, particularly of the type disclosed in the aforesaid application Ser. No. 08/634,592. Because the cable **146** is relatively free to slide with limited friction on the bushing **170** of the tensioning mechanism **148**, uniform tension is achieved throughout the cable length and consequently the resultant forces on the arms **142** is approximately the same for each position of tension adjustment. Correspondingly, the forces exerted on each pivotable arm **154** are approximately equal minimizing or eliminating binding or racking of the support members **156** as they are raised or lowered.

While the invention has been described in connection with preferred embodiments thereof it will be apparent to those skilled in the art that many changes and modifications may be made without departing from the true spirit and scope of the invention. Accordingly, it is intended by the appended claims to cover all such changes and modifications as come within the true spirit and scope of the invention.

What is claimed is:

1. An adjustable load bearing support structure comprising:

a base frame;

a generally planar support surface member;

a pair of adjustable support assemblies configured to support said support surface member for vertical movement relative to said base frame;

a pair of arms each being mounted for pivotable movement about an axis disposed beneath said support surface member and each having a free end provided with means for engaging one of said support assemblies;

a torsion spring connected to each arm, each spring having a central axis substantially coincident with the axis of pivotable movement of each respective arm and configured to exert a biasing force on each respective arm which force is transferred by each arm to one of said support assemblies;

a lever arm connected to each torsion spring and being configured to preload said springs when said lever arms are rotated;

a cable connecting said lever arms; and

means for tensioning said cable and thereby causing said lever arms to rotate and preload said springs.

2. The support structure of claim **1** wherein said tensioning means includes a movable bushing over which said cable passes.

3. The support structure of claim **2** wherein said tensioning means includes a threaded shaft threadedly connected to said bushing for adjustably moving said bushing when said shaft is rotated.

4. The support structure of claim **1** wherein said cable is endless and passes around a distal end of each lever arm.

5. The support structure of claim **4** wherein said cable is retained in slots formed in said lever arms.

6. The support structure of claim **1** wherein said free ends of said pivotable arms are provided with cam surfaces and said cam surfaces engage said support assemblies.

7. The support structure of claim **1** wherein said support assemblies include slide members for vertical movement of said support surface member.

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